Structural and Chemical Transformations of Pyrrhotite and Pentlandite: On the Possibility of Application of High-Power Nanosecond Pulses to Flotation Separation of Sulfide Minerals

Igor Zh. Bunin, Valentine A. Chanturiya, Alexey T. Kovalev, Irina A. Khabarova and Elizaveta V. Koporulina
Russian Academy of Sciences, Research Institute of Comprehensive Exploitation of Mineral Resources RAS
Moscow, Russia

ABSTRACT
The paper presents new theoretical and experimental results about mechanisms of disintegration of mineral complexes and structural transformations of the sulfide surface under high-power nanosecond electromagnetic pulses (HPEMP). The heated gas outflow from nanosecond breakdown channels of sulfide minerals under HPEMP is considered. It is shown that the gas outflow from channels can be an additional destructive factor in the processes of the electric pulse discharge disintegration of mineral complexes. It is shown that the effect of HPEMP changes chemical surface composition and, respectively, technological properties of pyrrhotite and pentlandite. Morphology and elementary composition of new micro- and nanoformations on mineral surface of pentlandite and pyrrhotite have been investigated using up-to-date methods of SEM/EDX and Scanning Probe Microscopy. Preliminary electropulse effect on mineral products before flotation allows producing optimal conditions for flotation separation of pentlandite and pyrrhotite owing to forming the new nanophases and defects on the surface of sulfides.

KEY WORDS: Sulfide mineral; high-power nanosecond pulses; electric breakdown channels; surface new-phases; flotation.

INTRODUCTION
The effectiveness of High-Power Nanosecond Pulses in the disintegration and liberation of fine-disseminated mineral complexes and the recovery of micro- and nanoparticles of precious metals from refractory ores was demonstrated in (Bunin et al., 2001; Chanturiya et al., 2001, 2003, 2005; Chanturiya and Bunin, 2005, 2007). Possible mechanisms of selective disintegration were considered in (Bunin et al., 2001; Chanturiya et al., 2003, 2006; Chanturiya and Bunin, 2005, 2007). It has been shown both theoretically and experimentally that electric breakdowns can play an important role in the nanosecond pulsed treatment of milled minerals (e.g., semiconductor sulfides and quartz with particle sizes of 100 μm to 2–3 mm) that are carriers of finely disseminated gold and other valuable components.

Electric discharges in such minerals are accompanied by a destruction of integrity in the form of breakdown channels and the formation of a system of cracks around these channels (Chanturiya et al., 2006; Chanturiya and Bunin, 2007). The development of the domains of induced cracks around the channels is determined by the pressure of evaporated material in the breakdown channel. Upon an instantaneous energy release in a channel (nanosecond discharges), the change in its transverse size and in the gas density and pressure in the channel is determined by (i) the radial motion of the evaporation wave, (ii) the radial expansion of the channel, and (iii) the heated gas outflow from the channel. The evaporation wave moves with a speed on the same order of magnitude as the speed of sound (or greater) and travels a distance of around the initial channel radius, i.e., a much smaller distance than the breakdown channel length. The expansion time for the material around the channel is determined by the dynamics of disintegration and crack development, and can be comparable to the time of gas outflow from the channel. In (Chanturiya et al., 2006), the sizes of the damaged regions were calculated on the assumption that the gas does not outflow from a channel during microcrack development. The theoretical purpose of this study was to consider the role of gas outflow from the channel.

THE ROLE OF GAS OUTFLOW FROM NANOSECOND BREAKDOWN CHANNELS IN THE ELECTRIC-PULSE DISINTEGRATION OF SULFIDE MINERALS
Let us assume that a breakdown channel has been formed by gas outflow onset and that the gas flows out from a long cylindrical channel with uniformly distributed density and pressure into a medium having much less density and pressure. The pressure gradient near the channel opening generates a rarefaction wave along the channel axis. The time of material outflow from the channel is determined by the passage of the rarefaction wave along the channel and its interaction with the reflected wave (in the case of nonthrough breakdown). For an inviscid gas, the density and pressure are independent of the channel radius, and the problem is one-dimensional. For an ideal gas with adiabatic index $\gamma$, 

195